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The AMERICAN JOURNAL of OPTOMETRY

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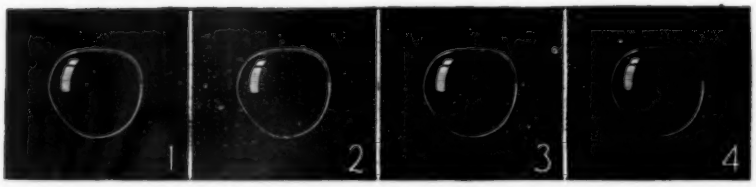

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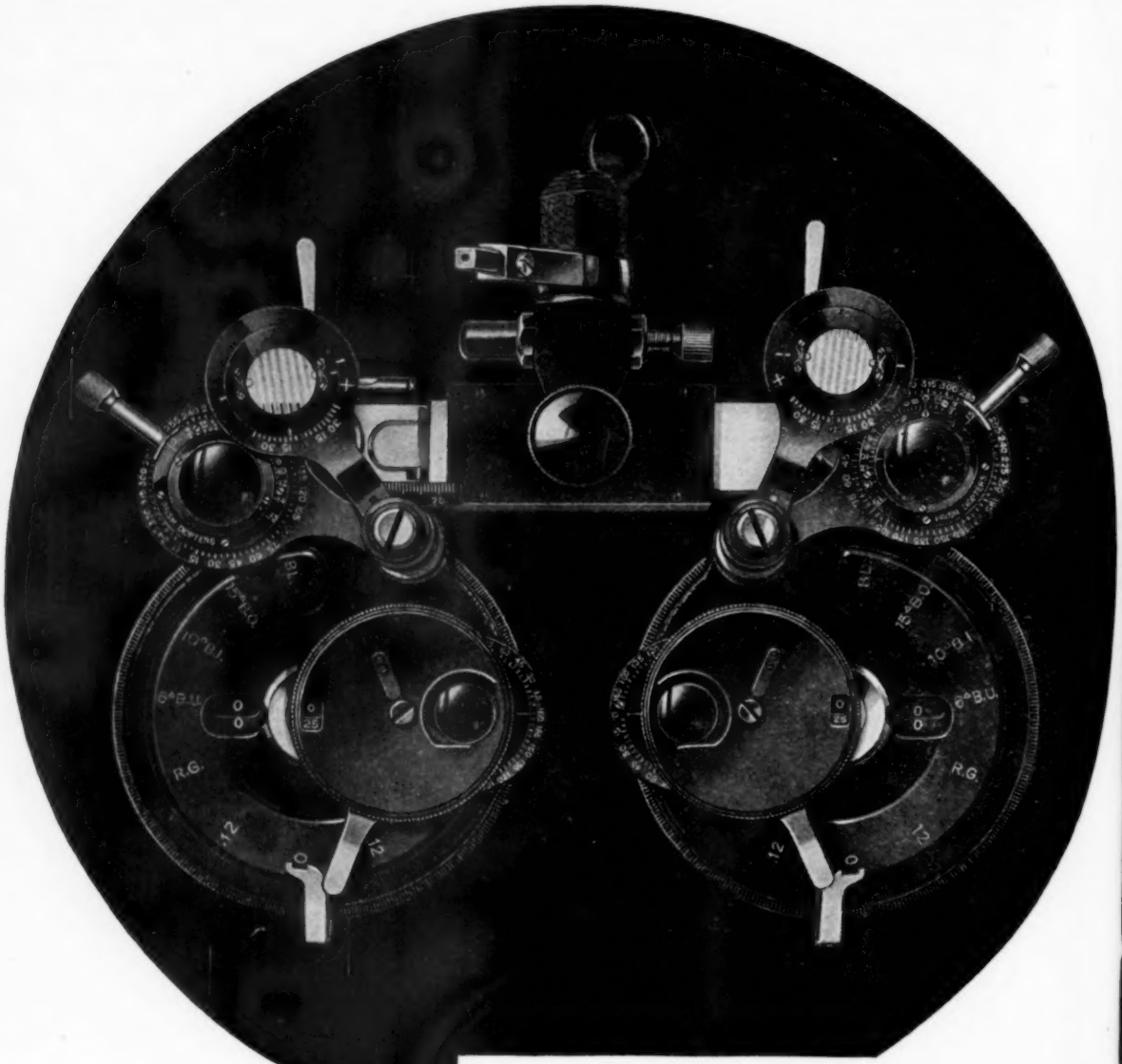

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AMERICAN JOURNAL OF OPTOMETRY

Vol. 12 MARCH, 1935 No. 3

A PORTABLE RESEARCH CLINIC AND ITS VALUE*

Alvhh R. Lauer
Associate Professor of Psychology
Iowa State College
Ames, Iowa

In 1928, the American Optometric Association inaugurated a series of researches to ascertain the visual limitations of automotive drivers. Under the efficient chairmanship of Dr. Edwin H. Silver of Washington, D. C., the project was launched at the Ohio State University in cooperation with the National Research Council. It was placed in the hands of the late Dr. A. P. Weiss, an internationally known experimental psychologist.

Basic scientific studies were inaugurated which have grown under the sponsorship of the Association to have obtained international recognition. By broadening the studies the general public has been interested in data which would not have gotten out of the profession if carried on as regular clinical research. In other words, the project has been made a cooperative problem in which funds from the Association were matched by approximately double the amount in services of research workers, equipment, facilities, and funds of large educational institutions. In this way, a much more philanthropic and impressive program has been carried out. In a similar way, a host of agencies have been enlisted in the cause such as: the National Safety Council, the Better Vision Institute, the press, nationally known periodicals, public schools, colleges, service clubs, the American Legion, women's clubs and many other groups.

To the writer's knowledge, several hundred newspapers have devoted columns to this work. Such newspapers as the St. Louis Post Dispatch and the Toronto Star have given full page descriptions of the studies with illustrations. The National Safety News has published about a dozen long articles on phases of the work. The Atlantic Monthly, Popular Science, Modern Mechanix, Popular Science Monthly and the Scientific Monthly (official organ for the American Association for the Advancement of Science) have carried long orthodox descriptions of the researches. In addition, numerous technical articles have appeared in the

*Submitted for publication February 10, 1935.

scientific journals. Requests for information have come from New Zealand, South Africa, Czechoslovakia, the Philippine Islands, Hawaii, and other centers abroad.

Of course, there could not be appended to all of these articles a definite recognition of all the agencies which have contributed. In fact, such an attempt would have labelled the project as mercenary or commercial and would have barred the articles as a form of advertising. No one has profited by the study directly or indirectly, in any way, so far as commercializing it is concerned. By keeping the project purely philanthropic, much more rapid progress has been made. It goes without saying that everyone having anything to do with professions related to it will find an opportunity for much wider service by virtue of so much public attention. It has been the distinct aim of all directly concerned to keep the good work untainted by unfavorable publicity. In journals where such recognition is appropriate credit has been given the proper sources.

A few references are cited here for the benefit of those who wish to inform themselves of the development of the project.

1. Disabilities that cause accidents. National Safety News. 1932, *26*, No. 4; 48-49 and 86-87.
* 2. Visual defects and human behavior. Optical Journal. 1930, *65*, 18-20. Lauer, A. R., Ellis, C. R., and Hare, R. A.
3. Are driver's examinations scientific? National Safety News. 1931, *23*; 42-44.
4. Psychological principles in automotive driving. The Ohio State University Press. 1930, *11*; 165. With A. P. Weiss.
* 5. The eyes behind the windshield. National Safety News. 1932, *26*, No. 5; 34 and 36.
6. How can we measure driving ability? National Safety News. 1932, *26*, No. 1; 25-26 and 64-65.
7. Recklessness in driving. National Safety News. 1932, *26*, No. 6; 17-19 and 61.
8. The role of psychology in accident prevention. National Safety News. 1932, *25*, No. 3; 19-20 and 68-69.
9. What types of persons have accidents? National Safety News. 1932, *26*, No. 2; 16-17 and 64.
10. Highway Safety—needed improvements. American Highways. 1933, *12*, No. 3; 13-14 and 17.
11. Are you safe to drive? Atlantic Monthly. 1934. Curtis Billings.
12. Same condensed in the Reader's Digest for March, 1934.
13. Science measures the driver's defects. National Safety News, 1934, *30*, No. 1; 9-11 and 48. Curtis Billings.
*14. Lighting conditions and other factors to be considered in the use of the Clason acuity meter. Amer. Jour. Optometry. 1933, *10*, No. 6; 194-200.
*15. Automotive manipulation in relation to vision. Jour. Appl. Psychol. 1934, *18*, No. 5; 422-431.
16. How well can the driver see? National Safety News, 1935, No. 3, 19-20. News. (In press.)

A short description of the driving clinic will be outlined with a few photographs of the important key units. To secure the attention of

---

*Those starred deal exclusively with visual defects. Practically all others discuss visual defects along with other factors of safety. The articles with author not indicated were by the writer of this paper.

parties interested in safety a complete set of units must be developed. This has been accomplished to some extent by the following means.

1. A Fargo truck furnished by the Chrysler Corporation is used to carry the equipment and laboratory is carried in the trailer. (See Figure I.)

FIGURE I.

Showing two-wheel trailer laboratory hitched to truck for rapid transportation. The truck has three seats for assistants and luggage. When on tour a camping outfit is used to reduce expenses. The instruments are packed in the cabinet on the trailer and in rear of truck. In case of rain it is shielded by a canvas cover.

2. A complete set of visual and other tests including the following:
   a. Clason Acuity Meter with phoropter for measuring acuity, astigmatism, and the phorias. Maddox Rod with Stevens phorometer for measuring the phorias. (See Figure II.)
   b. Parson's test for ocular dominance, Ishihara test of color vision, and the Nuchols test of field of vision.
   c. Glarometer test of sensitivity of the retina to extraneous light. (Figures III and IV.)
   d. Cheiroscope for detecting scotoma.
   e. Specially built equipment for measuring distance judgment and accommodation time.

FIGURE II.

Visual acuity and astigmatism are measured by the Clason Acuity meter. The Stevens Phorometer attachment with a Maddox Rod makes measurements of the phorias easy and objective. Acuity measurements are made for both eyes separately and together, both with and without glasses. Astigmatic indices are obtained on each eye separately with the best correction the driver uses.

FIGURE III.

This shows the driver being examined for color vision, field of vision, and general knowledge of driving.

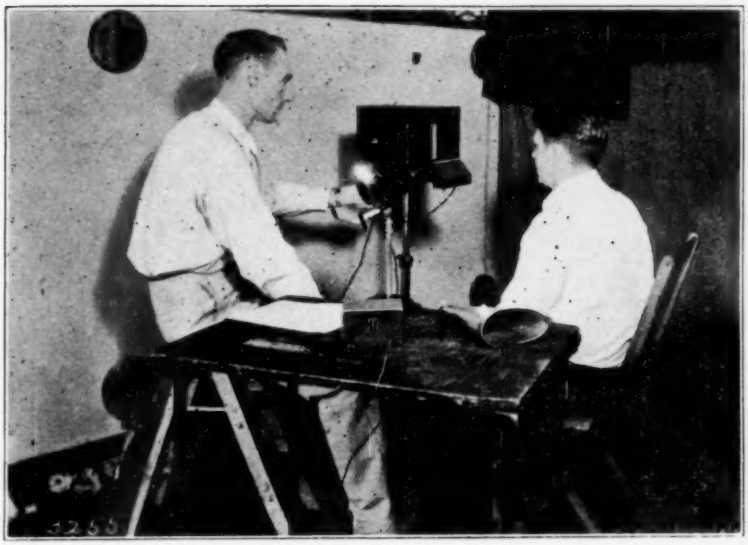

FIGURE IV.

The glarometer is used to measure the effect of strong light on the eye. Also included are measures of ocular dominance, depth perception, and other anomalies.

f. Special apparatus for measuring motor coordination, speed of movement, reaction time, strength, and mechanical intelligence.
g. Objective tests of blood pressure and auditory acuity.
h. A composite performance test for measuring reactions similar to actual driving. This apparatus is shown in Figure V.

Within a short time the assembly and standardization program will be completed. The larger units will need to be reduced in size and if possible the entire equipment fitted into a long body panel truck for rapid transportation.

The clinic has a great deal of possibility as an educational venture as well as for research in industrial plants and in its present status is admirably adapted for service to large industrial concerns. By cooperation with factories and production plants a wealth of data could be secured on visual efficiency and fatigue as well as that of instilling a public consciousness in the care of the eyes. It is hoped that such a unit may be assembled for use in industrial plants. The service could be offered to industrial companies for a nominal fee to take care of overhead. It would be possible to spend some three months a year in such kind of work which should be of the utmost value to the companies as well as to the profession as a whole.

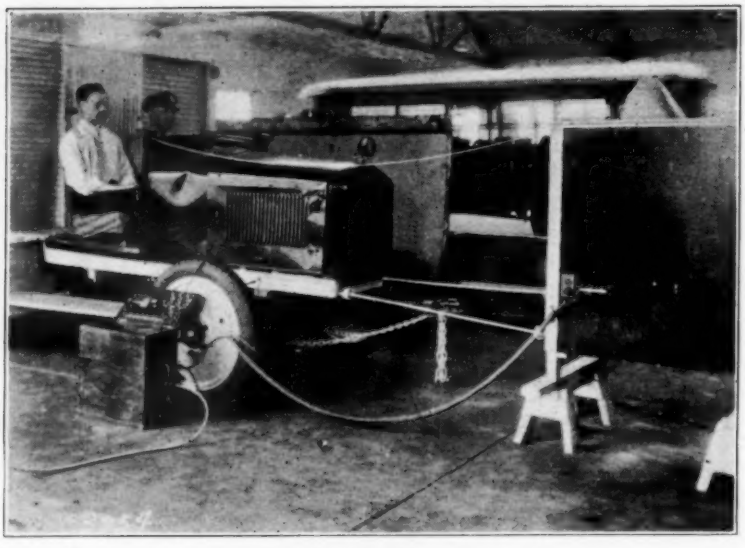

FIGURE V.

Showing the driving apparatus in action. The subject is seated at the wheel and his performance is checked by the experimenter sitting beside him. Brake, clutch pedal, gear shift, and steering wheel measurements are recorded automatically by an electric counting device. That used at present is a very small box, about the size of a taxi meter. When en route, the front wheels are carried in the cabinet and the trailer is pulled on two wheels.

Certain abbreviations in procedure would be made in the above described apparatus but the general effect would be essentially the same. By incorporating the driving units, entrance could be obtained whereas an approach on visual grounds alone would not be entertained. Your chairman, Dr. Edwin H. Silver, would like to hear your reactions to such a plan. It has been discussed in more or less detail and can be developed as permanent project. If this is not done by the A. O. A. it will likely be done by some other organization.

DR. ALVHH R. LAUER
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A STUDY OF FACTORS ENTERING INTO THE DETERMINATION OF HANDEDNESS*

Lewis H. Kraskin, O. D., F. A. A. O.
Washington, D. C.

Part III

(Continued from February issue.)

Investigation of some theories of handedness factors; Experimental Procedure involved in that Investigation, and Statement of Statistical Results.

In order to determine the effect of a right-handed world on the dexterity of the individual, cross sections of the life span from the infant to the adult were studied, namely, an infant group, a kindergarten group, a sixth grade group, and a college group. It was thought that if handedness were greatly influenced by environment, the infant group should be found to be almost wholly ambidextrous, and the adult group almost wholly right-handed. On the other hand if native handedness were determined entirely by heredity, the infant group along with each of the other groups should show about the same degree of right- and left-handedness. Further, it was thought that if handedness were determined by an heredity which allowed for a modification of that heredity by a right-handed world, the trend of the degree of left-handedness, as age increased, should be downward to the extent that older individuals had longer periods of time in which to adapt themselves to a right-handed world.

Infant Group.

To begin this study, statistical factors which might influence handedness both during the pre-natal stage and the post-natal stage were considered. Four pre-natal factors which might be related to handedness were investigated, the first of which was the dominant position of the foetus before birth and the presentation position of the child at birth. The reasons for believing that dominant pre-natal position might have something to do with the determination of handedness may be briefly stated.

It is well known that during the last three to six weeks before birth the position of the foetus becomes relatively fixed. In head

*Submitted for publication July 15th, 1934.

presentations, which make up practically all deliveries, the left arm is pinned against the mother's bony parts and the right arm is free to move, or the right arm is impinged against the mother's bony parts and the left arm is free. It has been noted, further, that the percentages of babies that have the presentation in which the left arm is in a fixed position and the right arm free, corresponds roughly with the percentage of right-handedness found in adult life, and that the percentage of babies that have the presentation in which the right arm is in a fixed position and the left arm free to move corresponds roughly with the percentage of left-handedness found in adult life. Dr. F. A. Moss made this interesting observation, and in order to carefully investigate it, secured the co-operation of Dr. H. W. Lawson, former professor and head of the department of Obstetrics in George Washington University, and Dr. Howard Kane, professor of Obstetrics, in George Washington University. These men kept a detailed record of the position of the foetus during the last part of pregnancy—in most cases the records were especially detailed for the last three months of pregnancy.

The Lawson and Kane records which contained the material concerning those pre-natal factors that might be supposed to be related to handedness were carefully investigated. A total of 486 cases were studied in an endeavor to ascertain the relation, if any, of the presentation position of the foetus to dextrality. There were 330 cases in one group, and 156 cases in the other. The results of the study are given in Table No. 3.

It will be observed that the LOA and ROA groups include 91.8 per cent of the 330 cases, and that 79 per cent of this 91.8 per cent of the cases are right-handed.

Furthermore, 80 per cent of the LOA and 78 per cent of the ROA were right-handed. It is also interesting to note the percentages of right-handedness in the other 8.2 per cent of the 330 cases, where the percentages are based on very much smaller samplings, i. e., the percentage of right-handedness for the LSA group is 77 per cent, for the LSP group it is 80 per cent, for the RSP it is 80 per cent, for the RSA with only two cases, however, it is 100 per cent, and for the ROP with only six cases it is 66 per cent.

It will be observed that the LOA and ROA groups contain 73 per cent of the 156 cases, and that 87.5 per cent of these combined groups are right-handed. Furthermore, 85 per cent of the LOA and 90 per cent of the ROA were right-handed. The scarcity of data detracts from the value of the observations of the other presentation positions, i. e., there were five cases with the LSA presentation position who were also right-handed with no left-handed observations, and, hence, the 100 per cent right-handedness for that group. Also there were two RSA presentations both of which were right-handed; hence the 100 per cent right-handedness for the RSA group. There were no LSP presentations noted, and only one RSP which one was right-handed, and hence the 100 per cent right-handedness for this group.

TABLE 3

CHART NUMBER ONE CONTAINING 330 CASES—STUDY OF PRESENTATION POSITION AND HANDEDNESS

	Delivery Postion	L	O	A	R	O	A	L	S	A	L	S	P
	Handedness	R	A	L	R	A	L	R	A	L	R	A	L
300 cases	Number	157	5	32	86	3	20	7	0	2	4	0	1
	Per Cent	80	3	16	78	3	18	77	0	22	80	0	20
156 cases	Number	78	0	14	19	----	2	5	----	----	----	----	----
	Per Cent	85	----	15	90	----	9	100	----	----	----	----	----

	Delivery Position	R	S	P	R	S	A	R	O	P	L	O	P
	Handedness	R	A	L	R	A	L	R	A	L	R	A	L
300 cases	Number	4	0	1	2	0	0	4	0	2			
	Per Cent	80	0	20	100	----	----	66	----	33			
156 cases	Number	1	----	----	2	----	----	23	----	7	5	----	----
	Per Cent	100	----	----	100	----	----	76	----	23	100	----	----

ROA is Right, Occipito-Anterior Presentation.

LOA is Left, Occipito-Anterior Presentation, etc.

The ROP group may be considered large enough to have some significance. There were 23 observations of right-handedness and seven observations of left-handedness. In other words, 76 per cent of that group was right-handed and 23 per cent was left-handed. The LOP group contained only five observations all of which were of right-handed subjects, and hence, the 100 per cent right-handedness for this group.

In the total of 486 observations, 89.6 per cent of all of the cases fall within the LOA and ROA groups, and 83.2 per cent of the cases within these LOA and ROA groups are right-handed.

Of the total 486 observations 81.7 per cent are right-handed and 18.3 per cent are left-handed.

Much of the value of the above data must be determined by the value of the tests for handedness which were given to the babies.

The manner of testing for handedness in this infant group was necessarily different from the recognized tapping test for handedness which was used in the other three divisions of this study. In most instances it was necessary to depend upon the telephone report of the mother regarding the handedness of her child. However, a sufficiently large group were actually tested by a test which was quite objective in all its phases save one to afford a standard of comparison for the subjective judgments given by the mothers. The subjective element in the above indicated test was that there were as many testers as there were children tested, in other words, each mother tested her own child. The test itself consisted of two government penny post cards on the same sheet folded together. Samples of the cards used are shown below:

(Part 1 of Record Card)

"Dear Mrs. 8/1/32

I am interested in the problem of the cause of right and left handedness. If you will make the following simple tests with your child, it will help me greatly.

1. On each of four days offer your child ten times each day some one object he desires.

2. Hold the desired object directly in front of your child so that no preference can be given either hand.

3. Record on the accompanying card the number of times your child reaches with the right hand and the number of times with the left.

I appreciate your gracious co-operation, and I am always at your service.

Faithfully yours, HOWARD F. KANE.

(Part 2 of Record Card)

Are any of your child's relatives left-handed? ..... Approximately at what age did your child have the first tooth? .....

	First Day		Second Day		Third Day		Fourth Day	
	R. Hand	L. Hand	R. Hand	L. Hand	R. Hand	L. Hand	R. Hand	L. Hand
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								

It was found that 82.2 per cent of the 138 cases for which cards were available were right-handed babies, and that 17.1 per cent were left-handed babies. It is extremely interesting to note the close correspondence in the dextrality percentages reported by the mothers and those actually found by the tests: There was 81.7 per cent right-handedness reported as contrasted with the 82.2 per cent found through the tests, and 18.3 per cent left-handedness reported as contrasted with the 17.8 per cent found through the tests.

Realizing that the tendency of most people is to consider left-handedness as an undesirable trait, it is only fair to suggest that the margin of doubt in this subjective testing lies on the side of the percentages of right-handedness. In other words, it would seem probable that a truly objective test objectively administered might give a greater extent of left-handedness.

The percentage of right-handedness is so nearly the same for each of the major birth presentation groups, that the results of this section of the study seem to show conclusively that the dominant position of the child in the uterus of the mother and the birth presentation position of the child are not related to its dexterity.

The second pre-natal factor to be investigated was the basal metabolism of the mother during pregnancy as related to the handedness of the infant. This study was made to investigate the hypothesis that if the pre-natal environment were a determinant in preferential handedness, the child of a mother with a tendency toward hyperthyroidism might show a tendency toward ambidexterity, whereas the child of a mother with a tendency toward hypothyroidism might be inclined to be either definitely right-handed or definitely left-handed. The theory back of this hypothesis was that the child of the hyperthyroid mother might be inclined to move about a great deal, and thus to move its arms both more vigorously and more often than the child of the hypothyroid mother.

It was found that within the 156 basal metabolism observations, the average basal metabolism of the mothers of ambidextrous children, 6 cases was —7.3, and of mothers of left-handed children 25 cases was —5.8, and of the mothers of right-handed children, 125 cases was —3.7. From these results it would seem that the basal metabolism of the mother and the handedness of her child are not related.

The third pre-natal factor to be investigated was that of birth weight. It was known that a big child would have a fixed position longer than a small one. This led to the hypothesis that the smaller babies would have a greater tendency toward ambidexterity than the larger ones. Also it was thought that the first factor might be a related factor and that large babies might tend toward one or the other of the major birth positions. The findings regarding the first factor made further investigation along this line unnecessary. There were 145 cases in this study. The average birth weight of a baby was found

to be 3,866 grams. There were found to be 23 left-handed cases in a total group of 145 cases, or 15.8 per cent. Consequently, there were 122 right-handed babies in the group of 145 cases or 84.1 per cent.

Seven of the twenty-three left-handed children had birth weights below the average of 3,866 grams, or that is, 30.4 per cent. Sixteen of the twenty-three left-handed children had birth weight above the average, or that is, 69.5 per cent. Seventy of the 122 right-handed children had birth weights below, or, that is, 57.3 per cent. The number of right-handed children above the average birth weight was found to be 52 or 42.6 per cent. There may be some relationship between low birth weight and the left-handedness, but it would seem that the seven left-handed cases below the average birth weight constitute too small a sample from which to draw conclusions regarding the 26.9 per cent difference between the percentage of left-handed children below the average birth weight and the percentage of right-handed children below the average birth weight.

TABLE NO. 4

No. of Cases								
23	Per cent		l.	handedness	in	group		= 15.8%
122	"	"	r.	"	"	"		= 84.1%
7	"	"	l.	"	"	"	children below average birth weight	= 30.4%
16	"	"	l.	"	"	"	children above average birth weight	= 69.5%
70	"	"	r.	"	"	"	children below average birth weight	= 57.3%
52	"	"	r.	"	"	"	children above average birth weight	= 42.6%

Heredity was the fourth pre-natal factor studied. It was believed that if heredity were a determining factor in handedness, the percentage of right-handed children with an entire right-handed heredity should be large, and the percentage of children with a mixed heredity should in so large a sample as is covered by the total number of cases studied in this entire investigation follow a rather definite trend as to the extent of right- and left-handedness. Attention is especially called to the term "mixed heredity." There were no cases of pure left-handed heredity reported.

The existence of left-handedness in the blood line was checked in 330 cases. Of these 330 subjects, 178 or 53.9 per cent were found to be right-handed with right-handed heredity; 86 or 26 per cent were

right-handed with left-handedness in the blood line; 16 or 4.9 per cent were left-handed with a right-handed heredity, and 50 or 15.2 per cent were left-handed with a left-handed heredity. Finally, it is noted that 58.8 per cent had an entirely right-handed heredity reported, and 41.2 per cent had an heredity in which there was some left-handedness reported. The entire group was found to contain 79.9 per cent right-handedness and 20.1 per cent left-handedness.

It is interesting to compare with these results the results of the above-mentioned study on the infants who were actually tested with the reaching test for forty trials. It was found in that total group of 137 that 67 right-handed babies or 48.9 per cent came from a right-handed blood line, and that 46 or 33.5 per cent of the right-handed babies had left-handedness in their family line, and that 14 left-handed babies or 10.2 per cent had left-handedness in their blood line, and that 10 left-handed babies or 7.3 per cent had an entire right-handed heredity. It was found then that 56.2 per cent of the entire group had a right-handed heredity and 43.7 per cent of the group had some left-handedness in the blood line, and that the entire group was found to contain 82.4 per cent right-handedness and 17.5 per cent left-handedness.

Perhaps the best way to illustrate the agreement of the two studies is by a chart:

TABLE NO. 5

INFANT GROUP—HEREDITY—STUDY I, 330 CASES

Subjects	Right Number	Heredity Per Cent	Left Number	Heredity Per Cent	Totals Per Cent
Right-handed . . .	178	53.9	86	26	79.9
Left-handed	16	4.9	50	15.2	20.1
Totals	194	58.8	136	41.2	100.0

TABLE NO. 6

HEREDITY—STUDY II, 137 CASES

Subjects	Right Number	Heredity Per Cent	Left Number	Heredity Per Cent	Totals Per Cent
Right-handed . . .	67	48.9	46	33.5	82.4
Left-handed	10	7.4	14	10.2	17.6
Totals	77	56.3	60	43.7	100.0

It must be remembered in studying this data that the 137 cases are included in the 330 cases.

It will be observed that 50 or 36.8 per cent of the 136 cases who had left-handedness in the blood line were left-handed cases as contrasted with the 16 or 8.27 per cent who were left-handed of the 194 cases who were reported to be entirely right-handed in the blood line. It would seem, therefore, that there may be an hereditary element involved here. On the other hand, studies on other groups indicate that extensive, careful experiments are necessary before definite conclusions can be drawn.

The relationship of the time of first tooth to handedness was the first post-natal factor to be investigated. It was thought that perhaps some of the research on the time of first tooth might be made use of here, and perhaps aid in finding some factor determining dexterity. It seemed especially desirable to study the relationship of late teething, left-handedness and inferiority.

Of the 330 cases 79.9 per cent of whom were found to be right-handed and 20.1 per cent of whom were found to be left-handed, it was found that 41.2 per cent of the 330 cases were right-handed and got the first tooth within six months, and that 9 per cent of the 330 cases were left-handed and got the first tooth within six months, and hence that 51.5 per cent of the right-handed babies received their first tooth within the first six months, and that 45 per cent of the left-handed babies received their first tooth within the first six months. If it is remembered, in considering the fact that 6.5 per cent more of the right-handed babies received their first tooth during the first six months of their lives than the left-handed babies, that the number of left-handed cases is only 9 per cent of the total 330 cases, it would seem that there is no relation between time of first tooth and dextrality.

The Kindergarten Group.

Before describing the kindergarten investigation it would seem desirable to discuss the experimental set-up and method of testing used not only for the kindergarten group, but also for the sixth grade and college groups which follow it.

After surveying the literature in order to find that test which had been found to be the best test of handedness, the tapping test was selected. The actual experimental set-up of the tapping test is a very simple one, consisting of four batteries, a telegraphic key, an electric counter and a stop watch.

Each subject was allowed to tap exactly sixty seconds. Care was taken that the subject understand what was expected of him before the tapping began. In order that the subject should not know that his handedness was being tested, and, hence, definitely try to prove himself as having one or another form of handedness, he was told that the test was one of reaction time. The subject was inspired to tap with a maximum effort in each hand in order that he might prove himself to have a high reaction time.

The results of this maximum tapping record for each hand were in turn used to define what might be termed a handedness ratio. The right count was placed over the left count in order to determine the subject's handedness ratio. The handedness ratio showed the extent of the subject's degree of handedness. For instance, if subject A tapped 330 with his right hand and 300 with his left, his handedness ratio would be 330/300 or 1.10. Similarly, if subject B tapped 300 with his right hand and 330 with his left, his handedness ratio would be 300/330 or .90. Subject A would then have shown a handedness ratio of more than one, and would, hence, be classed in the right-handed group, and subject B would have shown a handedness ratio of less than one and would, hence, be classed in the left-handed group. Theoretically, one is perfect ambidexterity, however, since we live in a right-handed world where every right-handed tendency is given full opportunity for development and every left-handed tendency is discouraged, the one is through this entire study consistently classed with the left-handed group. Due to the nature of the tests used and the statistical elements involved ambidexterity would actually be defined by an interval having one as its mid-point, for example, perhaps by the interval, .95 to 1.05, but for the purposes of this study it is not necessary to define what is meant by ambidexterity.

Since a conception of the handedness ratio is basic to an understanding of this work, a further discussion of the handedness ratio is in order. Perhaps one of the greatest advantages of such a ratio is that it describes always the relationship between the two hands; not the speed of reaction time, but the simple degree of handedness for each hand. For instance, if A taps 330/300 and, hence, obtains a ratio of 1.10, and D taps 400/300, and, hence, obtains a ratio of 1.33, we can at once conclude that D is approximately .23 more right-handed than A.

The degree of handedness is an important factor that does not seem to have been studied adequately. It was thought that handedness like every other trait, might be representable by a continuous function within limits, and it was believed that if it were found to be such a function, such an incidence would be indicative of the native quality of the trait. For all individuals live in very much the same type of right-handed world, and hence, if environment were the only determinant, all individuals would achieve approximately the same degree of right-handedness.

One might propose that human beings are not right-handed or left-handed; they are a given number of degrees right-handed and a given number of degrees left-handed. For instance, subject A registers 135 taps with the left hand and 200 taps with the right hand. To say that subject A is right-handed is not to adequately describe the handedness of subject A. For subject B taps 190 with his left hand and 200 with his right hand and he also is classed as right-handed. To say, however, that subject A is 200/135 or 1.48 in his handedness ratio,

and that subject B is 200/190 or 1.05 in his handedness ratio is to describe the degree of handedness in each instance. A frequency function for the distribution of handedness ratios is defined by the following data as found in Table No. 7.

A graphic representation of the frequency function is given in Drawing No. 1.

The Kindergarten group was studied as their handedness was related to two factors, the first of which was the degree of handedness and the second, intelligence, as measured in terms of intelligence quotients by the Simon-Binet scale.

It was found that 81.4 per cent of the total kindergarten group which consisted of 296 cases tapped more than one on the tapping test. The test indicated varying degrees of right-handedness. 18.6 per cent of the 296 tapped either exactly one or less than one. Again the test indicated varying degrees of left-handedness. The mean tapping rate of the entire distribution for the kindergarten group was found to be $1.110 \pm .005$. The chances are 1,000 to one that the mean of any other sample will be within the range of 4.88 times the probable error, or in other words, between 1.086 and 1.134.

The standard deviation of the distribution was found to be $.127 \pm .004$. The probable error here is sufficiently small for the standard deviation to have a high degree of significance, and the distribution can be approximated by a normal frequency function. However, further investigation reveals that the fourth moment is significant. The frequency function will be observed by referring to Table No. 7.

The 296 kindergarteners ranged in degrees of handedness from .70 to 1.65 with the mean as pointed out above falling at $1.110 \pm .005$.

If right-handedness were a matter of adapting one's self to a right-handed world, it might be supposed that the more intelligent the individual the more easily he would be able to adapt himself, and hence, if environment were the determining factor in preferential manipulation, a high positive correlation between right-handedness and intelligence could be expected. On the other hand, if no such correlation were found, it was thought that such an incidence would be indicative of a physiological basis for this very definite tendency in individuals to prefer one hand above another.

In order to study the relationship between intelligence and degree of handedness as measured by the handedness ratio, 160 subjects from the kindergarten group, for which both handedness ratios and Simon-Binet intelligence quotients were available, were arranged in the order of increasing handedness ratios and divided into deciles. The average handedness ratio and average intelligent quotient for each decile were calculated. These averages were then correlated to see if a linear rela-

TABLE NO. 7

KINDERGARTEN GROUP—FREQUENCY TABLE—TAPPING TEST

Class Interval	Deviation From *Assumed Mean	Frequency	First Moment	Second Moment
.70	—.40	1	—.40	.1600
.75	—.35	1	—.35	.1225
.80	—.30	3	—.90	.2700
.85	—.25	6	—1.50	.3750
.90	—.20	11	—2.20	.4400
.95	—.15	21	—3.15	.4725
1.00	—.10	50	—5.00	.2500
1.05	—.05	44	—2.20	.1100
*1.10	0	35	0	0
1.15	.05	32	1.60	.0800
1.20	.10	34	3.40	.3400
1.25	.15	22	3.30	.5000
1.30	.20	15	3.00	.6000
1.35	.25	10	2.50	.0625
1.40	.30	5	1.50	.0450
1.45	.35	1	.35	.1225
1.50	.40	4	1.60	.6400
1.55	.45	0	0	0
1.60	.50	1	.50	.2500
		296	3.08	4.7300

*Assumed mean = 1.10.

Calculation = Let x represent the mean minus the assumed mean

$$x = \frac{3.08}{296} = .007$$

Mean = 1.10 + .010 = 1.110

$\Sigma^2 = 4.7300 - .0001 = 6.05$

$$o'^2 = \frac{4.7299}{296} = .020439$$

$$o' = \sqrt{.0159793} = .1429$$

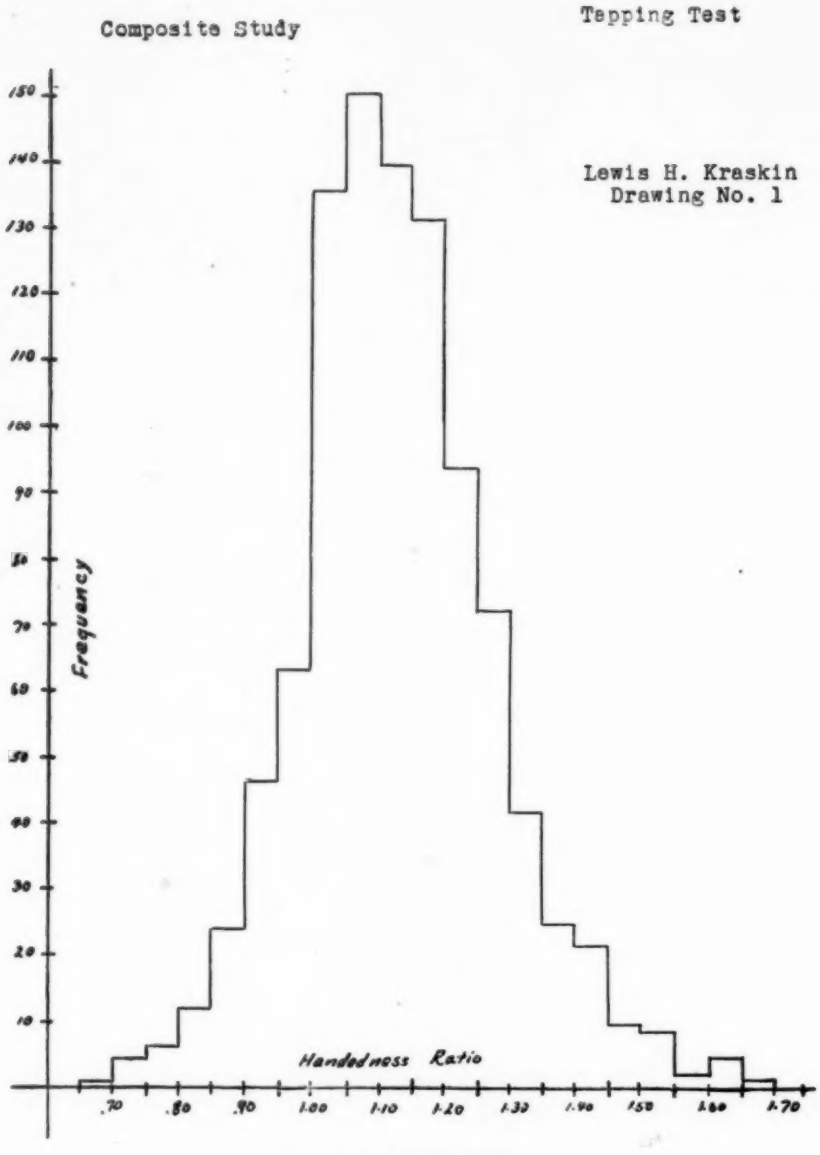
By well known formulas the probable errors, denoted by P. E., are:

$$\text{P. E. Mean} = \frac{.6745 \times .1429}{296} = \frac{.6745 \times .127}{17.2} = 00560$$

Hence The Mean = 1.110 ± .006

$$\text{P. E. } o' = \frac{.4769 \times .127}{17.2} = .00396$$

and hence o' = .127 ± .004.



FREQUENCY FUNCTION

tionship existed. The Pearsonian coefficient of correlation between the handedness ratios and intelligence quotients was found to be only —.14. In other words, no relation was found between dextrality as shown by the tapping test and intelligence as measured by the Simon-Binet tests. This study is shown in more detail in Table No. 8.

TABLE NO. 8

KINDERGARTEN GROUP—CORRELATION OF HANDEDNESS RATIO WITH INTELLIGENT QUOTIENT

Decile	Number	Averages: Tapping Ratio x	Averages: Intel. Quotient y	dx	dy	d^2x	d^2y	dx dy	d d
1	16	.87	100	—.25	—2	.0625	4	.50	-----
2	16	.98	94	—.14	—8	.0196	64	1.12	____
3	16	1.02	113	—.10	11	.0100	121	-----	1.10
4	16	1.05	100	—.07	—2	.0049	4	.14	____
5	16	1.09	105	—.03	3	.0009	9	-----	.09
6	16	1.14	99	.02	—3	.0004	9	-----	.06
7	16	1.19	108	.07	6	.0049	36	.42	-----
8	16	1.23	103	.11	1	.0121	1	.11	____
9	16	1.28	98	.16	—4	.0256	16	-----	.64
10	16	1.40	100	.28	—2	.1064	4	-----	.56
	160	11.25 mean 1.12	1020 mean 102			.2473	268	1.29	2.45
								dx dy = —1.16	

Calculations: Let dx represent the deviation of the tapping ratio from the mean 1.12 and let dy represent the deviation of the intelligence quotient from the mean 102.0. Let r be the Pearsonian correlation coefficient. Then,

$$r = \frac{-1.16}{\sqrt{.2473 \times 268}} = \frac{-1.16}{\sqrt{66.2764}} = \frac{-1.16}{8.14} = -1.42$$

Probable error of $r = .6745x(1 - r^2) / \sqrt{N} = .052$

$r = -.142 \pm .052.$

The next study consisted in determining whether extremes of handedness and intelligence were related. To accomplish this, each tapping ratio below the mean, 1.12, was replaced by another obtained by adding the difference between it and the mean to the mean, thus .87 (Table No. 8) was replaced by 1.12 + (1.12 — .87) = 1.37. For this new series the Pearsonian coefficient of correlation was found to be —.10. In other words, no relationship was found between extremes of handedness and intelligence (Table No. 9).

The two studies described above seem to indicate that handedness as measured by the handedness ratio for the tapping test and intelligence as measured by the Simon-Binet tests are entirely independent, at least as far as the kindergarten group was concerned.

The Sixth Grade Group.

The same factors which led to a consideration of heredity in the infant group, and to a consideration of intelligence and degree of handedness in the kindergarten group led to a consideration of all three of those factors as related to handedness in the sixth grade group.

TABLE NO. 9

KINDERGARTEN GROUP—CORRELATION EXTREMES OF HANDEDNESS (RIGHT OR LEFT) AND INTELLIGENCE

TAPPING TEST

1.12 + .25 = 1.37	100
1.12 + .14 = 1.26	94
1.12 + .10 = 1.22	113
1.12 + .07 = 1.19	100
1.12 + .03 = 1.15	105
1.12 + .02 = 1.14	99

Calculations

Tapping Average	Intel. Quotient	dx	dy	d^2x	d^2y	dx+dy	dx—dy
1.14	99	—.10	—3	.0100	9	.30	.....
1.15	100	—.09	—2	.0081	4	.18	.....
1.19	100	—.05	—2	.0025	4	.10	.....
1.19	100	—.05	—2	.0025	4	.10	.....
1.22	113	—.02	—21	.0004	121	....	.22
1.23	103	—.01	11	.0001	1	....	.01
1.26	94	.02	—8	.0004	64	....	.16
1.28	98	.04	—8	.0016	16	....	.16
1.37	100	.13	—2	.0169	4	....	.26
1.40	100	.16	—2	.0256	4	....	.32
12.43				.0681	268	.68	—1.13
mean 1.24							.68
						dx dy =	— .45

$$r = \frac{.45}{\sqrt{.0681 \times 268}} = \frac{-.45}{\sqrt{18.2508}} = \frac{-.45}{4.27} = -.10$$

Probable error of r = .053

r = —.10 ± 0.53

The tapping test was given to 291 sixth graders. The percentage of subjects who tapped either exactly one or less than one in the 291 cases, was found to be 19.2 per cent. 80.8 per cent of the entire group of 291 subjects tapped more than one. The sixth graders ranged in degrees of handedness from .70 to 1.60. The mean was found to be 1.120 ± .006. For such a probable error, the chances are 1,000 to one that the mean of any other sample will be within the range of 1.120 ± .029, where .029 is 4.88 times the probable error, in other words, between 1.149 and 1.091. The standard deviation was found to be .1530 ± .0045. The frequency function is defined by the following table:

TABLE NO. 10

GRADE VI—FREQUENCY FUNCTION FOR HANDEDNESS RATIO—TAPPING TEST

Class	Deviation From *Assumed Mean	Frequency	First Moment	Second Moment
.70	—.45	2	—.90	.4050
.75	—.40	3	—1.20	.4800
.80	—.35	3	—1.05	.3675
.85	—.30	11	—3.30	.9900
.90	—.25	11	—2.75	.6875
.95	—.20	19	—3.80	.7600
1.00	—.15	30	—4.50	.0675
1.05	—.10	34	—3.40	.3400
1.10	—.05	38	—1.90	.0950
*1.15	0	42	0	0
1.20	.05	29	1.45	.0725
1.25	.10	27	2.70	.2700
1.30	.15	14	2.10	.3150
1.35	.20	13	2.60	.5200
1.40	.25	7	1.75	.4375
1.45	.30	4	1.20	.3600
1.50	.35	1	.35	.1225
1.55	.40	1	.40	.1600
1.60	.45	2	.90	.4050
		291	—9.35	6.8450 = S^2

*Assumed mean = 1.15.

Calculations: Let X represent the deviation of the mean from the assumed mean, 1.15, and let δ represent the standard deviation. Then $X = \frac{-9.35}{291} = -.032$ so that the mean is 1.15 —.03 = 1.12.

From the correction form $\Sigma^2 = S^2 - X^2 = 6.8450 - (.032)^2 = 6.8441$, it follows that $\delta^2 = \Sigma^2/N = \frac{0.8441}{291} = .0234337$, so that $\delta = .1530$.

Finally from the well known formulas the

$$\text{P. E. Mean} = \frac{.6745\delta}{\sqrt{N}} = \frac{.6745 \times .1530}{\sqrt{291}} = \frac{.6745 \times .1530}{16.1} = .00637$$

and hence $M = 1.12 \pm .006$

$$\text{P. E.}_{\delta} = \frac{.4769\delta}{\sqrt{N}} = \frac{.4769\delta}{\sqrt{291}} = \frac{.4769 \times .1530}{16.1} = .00450$$

and hence $\delta = .1530 \pm .0045$.

The first factor to be considered in this group of sixth graders was the degree of handedness. The general consideration which was given the kindergarten group holds here, and the specific handedness ratio or degree of handedness results for the sixth grade group are given in the paragraph above. The second column is the frequency function for the group (see Table No. 10).

The second factor to be considered was the relationship of handedness and intelligence in the sixth grade group. The Pearsonian coefficient of correlation between the handedness ratio and intelligence was found to be .6103 $\pm$ .0248. In other words, for the sixth grade group, there may be a relation between dextrality as shown by the tapping test, and intelligence as measured by the intelligence quotients of the Simon-Binet intelligence tests, but in view of other facts, it would seem more probable that the high intelligence quotient for the tenth decile is a chance one and that there is no relationship even here. Also, a definite study of ambidexterity and intelligence was made in which the absolute deviation of the handedness ratio from the mean is used for calculating the coefficient of correlation. The coefficient of correlation was found to be .42, so that there may be a relationship between ambidexterity as measured by the tapping test and the intelligence quotient as measured by the Simon-Binet tests for intelligence, but the observation made above applies here also.

The third factor to be checked was the relationship of heredity to dextrality. It must be pointed out, here, however, that these sixth grade children often seemed very uncertain regarding the handedness of their blood lines, and hence, too much emphasis is not to be placed on the data which is to be presented here. It is given in the hope that it may possibly be indicative of a truth which accurate scientific measurement may some day reveal.

In a study of 290 cases, the heredity was taken as the child stated it to be, and compared with the handedness ratio of the child determined by the tapping test. It was found that 178 or 61.3 per cent of the 290 cases with right-handed heredity tapped more than one. Forty-two, or 14.5 per cent of the 290 cases with right-handed heredity tapped either exactly one or less than one. Fifty-six, or 19.4 per cent of the 290 cases with left-handed heredity tapped more than one. Fourteen, or 4.8 per cent of the 290 cases with left-handed heredity tapped either exactly one or less than one.

In 290 cases we have the statements of the children as to their own handedness and that of their blood lines. It was found that 203, or 70.0 per cent of the total 290 children reported themselves as being right-handed and of right-handed heredity. Seventeen, or 5.8 per cent of the children reported themselves as being left-handed and of right-handed heredity. Sixty, or 20.7 per cent of the children reported themselves as being right-handed and of left-handed heredity. Ten, or 3.5

TABLE NO. 11

SIXTH GRADE CORRELATION OF INTELLIGENCE WITH HANDEDNESS RATIO—TAPPING TEST

Decile		Average Tapping Ratio X	Average I. Q. Y	dx	dy	d^2x	d^2y	dx dy	
1	29	.85	112.3	—.28	— .8	.0784	.64	.224	
2	"	.97	110.7	—.16	—2.4	.0256	5.76	.384	
3	"	1.03	106.1	—.10	—7.0	.0100	49.0	.70	
4	"	1.07	116.0	—.06	2.9	.0036	8.41	- - -	—.174
5	"	1.12	112.3	—.01	— .8	.0001	.64	.008	
6	"	1.15	109.8	.02	—3.3	.0004	10.89	------	—.066
7	"	1.18	115.2	.05	2.1	.0025	4.41	.105	
8	"	1.24	113.8	.11	.7	.0121	.49	.077	
9	"	1.29	112.7	.16	— .4	.0256	.16	-----	—.064
10	"	1.41	123.0	.28	9.9	.0784	98.01	2.772	
		11.31	1131.9			.2367	178.41	4.270	—.304

$M = 1.13 \qquad M = 113.1 \qquad dx\,dy = 3.966$

$$r = \frac{3.966}{\sqrt{.2367 \times 178.41}} = \frac{3.966}{\sqrt{42.229647}} = \frac{3.966}{6.498} = .6103$$

$$\text{P. E. } r = \frac{.6745\ (1-r^2)}{\sqrt{N}} = .02485;\ r = .6103 \pm .0248$$

per cent of the children reported themselves as being left-handed and of left-handed heredity.

The two groups may be more readily compared in the following chart as shown in Table 12.

It is interesting to remark here that all sixth grade children who said that they were left-handed, tested left-handed by the tapping test. On the other hand twenty-five of those who said that they were right-handed tested left-handed by the tapping test. Presumably these twenty-five would ordinarily have been left-handed, but due to environmental contacts in a right-handed world, they used their right hands more than their left hands and thus came to believe that they were right-handed.

It is observed that 80.7 per cent of the group of 290 showed varying degrees of right-handedness in that their handedness ratio was more than one, and that 19.3 per cent of the total number of subjects tapped either exactly one or less than one, thus indicating varying degrees of left-handedness. It is recorded that 75.8 per cent of the entire 290 cases reported a right-handed heredity.

RELATION OF INTELLIGENCE TO EXTREMES OF HANDEDNESS

	X	Y	dx	dy	dx^2	dy^2	dx dy
1	1.12	112.3	—.13	— .8	.0169	.64	.104
2	1.15	109.8	—.10	—3.3	.0100	10.89	.330
3	1.18	115.2	—.07	2.1	.0049	4.41	— .147
4	1.19	116.0	—.06	2.9	.0036	8.41	— .174
5	1.23	106.1	—.02	—7.0	.0004	49.00	.140
6	1.24	113.8	—.01	.7	.0001	.49	— .007
7	1.26	110.7	.01	—2.4	.0001	5.76	— .024
8	1.29	112.7	.04	— .4	.0016	.16	— .016
9	1.41	112.3	.16	— .8	.0256	.64	— .128
10	1.41	123.0	.16	9.9	.0256	98.01	1.584
	12.48	1131.9			.0888	178.41	1.662

Mean Tapping Ratio = 1.25 Mean Intelligent Quotient = 113.1

$$r = \frac{1.662}{\sqrt{.0888 \times 178.41}} = \frac{1.662}{\sqrt{15.842808}} = \frac{1.662}{3.979} = .4176$$

$$\text{P. E. } r = \frac{.6745\ (1-r^2)}{\sqrt{N}} = .0326;\ r = .4176 \pm .0326$$

Of the total of 70 who tested left-handed, 14, or 20 per cent reported left-handed heredity, whereas 43, or 19.1 per cent of 220 who reported right-handed heredity were left-handed. There may, therefore, be an heredity factor involved here, but the contrast is not as striking as in the case of the infants.

College Group.

The same considerations that led to a study of degrees of handedness, heredity, and intelligence in the studies which have been reported, led to a study of these three factors in connection with a college group. Besides these three studies two additional ones were made on the college group.

The same type of study on the degree of handedness was made on the college group as on the kindergarten and sixth grade groups. To begin the study, 398 cases in the college group were given the tapping

TABLE NO. 12

HANDEDNESS AND HEREDITY—SIXTH GRADE CHILDREN

SUBJECTS	RIGHT HEREDITY Number		RIGHT HEREDITY Per Cent		LEFT HEREDITY Number		LEFT HEREDITY Per Cent		TOTALS Per Cent	
	Test	State	Test	State	Test	State	Test	State	Test	State
R. Handed	178	203	61.3	70.0	56	60	19.4	20.7	80.7	90.7
L. Handed	42	17	14.5	5.8	14	10	4.8	3.5	19.3	9.3
Totals	220	220	75.8	75.8	70	70	24.2	24.2	100.0	100.0

test. Of these 82.7 per cent tapped more than one, and 17.3 per cent tapped either exactly one or less than one.

Varying degrees of handedness were indicated. The college group ranged in degrees of handedness as exhibited by the handedness ratio from .65 to 1.65 with the mean of the 398 cases at 1.091 ± .00467.

The chances are 1,000 to one that the mean of any other similar sample will lie between 1.091 ± .023 where .023 is 4.88 times the probable error.

The standard deviation was found to be .138 ± .0033. A table presenting the frequency distribution for this study is shown in Table No. 13.

Intelligence data was not available for the students who took the tapping test, but it was available for a group who were given a special number marking test which is described later. The coefficient of correlation between the handedness ratio for the number marking test and intelligence as indicated by the Mental Alertness test, George Washington University series, was found to be only .00948. In other words, there is no relationship between dextrality as shown by the marking test and intelligence, as shown by the Mental Alertness test of the George Washington University series. Also, a definite study of ambidexterity and intelligence was made in which the absolute deviation of the handedness ratio from the mean is used for calculating the coefficient of correlation. The coefficient of correlation was found to be .150 ± .043 indicating that there is no relationship between ambidexterity as measured by the marking test and intelligence as measured by the Mental Alertness test of the George Washington University series (see Table No. 14). It is interesting to observe that the findings of this study agree with the findings of the kindergarten study even though the marking test and not the tapping test is the test for handedness here, and the Mental Alertness test of the George Washington University series is the test for intelligence and not the Simon-Binet Intelligence test.

The third factor to be investigated was the relationship of handedness as shown in the tapping test, and heredity as reported by the students. It was found that 17.2 per cent of the total group of 394 were left-handed, and that 82.8 per cent of the total group were right-handed. 61.5 per cent of the total group were right-handed with a right heredity, and 12.6 per cent of the group were left-handed with a right heredity. 21.3 per cent of the total group were right-handed with a left heredity, and 4.6 per cent of the group were left-handed with a left heredity. This data may be more clearly seen in the following chart as shown in Table 16.

The fourth factor in the college group which was studied as a handedness factor was the strength of grip in each hand. It was believed

TABLE NO. 13

COLLEGE STUDENTS—FREQUENCY TABLE—TAPPING TEST

Class X	Deviation From *Assumed Mean	Frequency F	First Moment	Second Moment
.65	—.45	1	—.45	.2025
.70	—.40	1	—.40	.1600
.75	—.35	2	—.70	.2450
.80	—.30	6	—1.80	.5400
.85	—.25	6	—1.50	.3750
.90	—.20	24	—4.80	.9600
.95	—.15	23	—3.45	.5175
1.00	—.10	55	—5.50	.5500
1.05	—.05	72	—3.60	.1800
*1.10	0	66	0	0
1.15	.05	57	2.85	.1425
1.20	.10	30	3.00	.3000
1.25	.15	23	3.45	.5175
1.30	.20	12	2.40	.4800
1.35	.25	1	.25	.0625
1.40	.30	9	2.70	.8100
1.45	.35	4	1.40	.4900
1.50	.40	3	1.20	.4800
1.55	.45	1	.45	.2025
1.60	.50	1	.50	.2500
1.65	.55	1	.55	.3025
		398	—3.45	7.7675 = S^2

*Assumed mean = 1.10.

Calculations: Same symbols used as in previous studies.

$x = -3.45/398 = -.0086$; $\Sigma^2 = S^2 - x^2 = 7.7675 - (-.0086)^2 = 7.7761$.

Mean = 1.10 — .0086 = 1.091 = M.

$o'^2 = \Sigma^2/N = 7.7761/398 = .019537$.
$o' = .138$.

P. E. of mean = $.6745\ o'/\sqrt{N} = .6745 \times .138/19.9 = .00467$.
Mean = 1.091 ± .0047.

P. E. of $o' = .4769\ o'/\sqrt{N} = .4769 \times .138/19.9 = .0331$.
$o' = .138 \pm .0033$.

TABLE NO. 14

COLLEGE STUDENTS—CORRELATION OF INTELLIGENCE WITH HANDEDNESS RATIO—NUMBER-MARKING TEST

Decile	No.	——Averages—— Marking Ratio x	Mental Alertness y	dx	dy	d^2x	d^2y	dx dy
1	24	.98	131.8	—.74	.1	.5476	.01	— .074
2	24	1.28	126.7	—.44	— 5.0	.1936	25.00	2.200
3	24	1.47	132.4	—.25	.7	.0625	.49	— .175
4	24	1.55	143.2	—.17	11.5	.0289	132.25	—1.955
5	24	1.64	124.0	—.08	— 7.7	.0064	59.29	.616
6	24	1.73	120.8	.01	—10.9	.0001	118.81	— .109
7	24	1.84	139.0	.12	7.3	.0144	53.29	.876
8	24	1.98	132.3	.26	.6	.0676	.36	.156
9	24	2.18	142.3	.46	10.6	.2116	112.36	4.876
10	24	2.58	124.6	.86	— 7.1	.7396	50.41	—6.106
	240	17.23	1317.1			1.8723	552.27	.305

Mean 1.72 131.7; $r = \frac{.305}{\sqrt{1.8723 \times 552.27}} = .0095$

P. E. $r = \frac{.6745\ (1-r^2)}{\sqrt{N}} = \frac{.6745}{\sqrt{240}} = .043$ which is greater than r

TABLE NO. 15

RELATION OF INTELLIGENCE TO EXTREMES OF HANDEDNESS

	x	y	dx	dy	d^2x	d^2y	dx dy
1	1.73	120.8	—.33	—10.9	.1089	118.81	3.597
2	1.80	124.0	—.26	— 7.7	.0676	59.29	2.002
3	1.84	139.0	—.22	7.3	.0484	53.29	—1.606
4	1.89	143.2	—.17	11.5	.0289	132.25	—1.955
5	1.97	132.4	—.09	.7	.0081	.49	— .063
6	1.98	132.3	—.08	.6	.0064	.36	— .048
7	2.16	126.7	.10	— 5.0	.0100	25.00	— .500
8	2.18	142.3	.12	10.6	.0144	112.36	1.272
9	2.46	131.8	.40	.1	.1600	.01	.040
10	2.58	124.6	.52	— 7.1	.2704	50.41	—3.692
	20.59	1317.1			.7231	552.27	— .953

Mean 2.06 131.7

$r = \frac{-.953}{\sqrt{.7231 \times 552.27}} = -.150$ P. E. r = .043

r is less than four times P. E. r and hence not significant.

TABLE NO. 16

HEREDITY AND HANDEDNESS IN THE COLLEGE GROUP—394 CASES

RIGHT HEREDITY		LEFT HEREDITY		TOTAL
Right Hand	61.5%	Right Hand	21.3%	82.8%
Left Hand	12.6%	Left Hand	4.6%	17.2%

that the preferred hand would very probably be the strongest hand: should this be true, it was believed that such an incidence would be indicative of the native quality of the trait; in as much as strength is entirely a physiological factor, and preferential dextrality is manifested before the individual has had time to build up the strength factor. In other words, it was believed that a high positive relationship between strength and the preferred hand might be indicative of an equally high relationship between strength and native handedness.

This strength of grip test was given to each of 242 subjects. The average of three trials in each hand was taken, the test having been given first to one hand, and then to the other. The purpose of the test was to check the tapping test as a measure of handedness, and to note the relationship of strength of grip to handedness. It was found that 25 per cent of the total 242 subjects had a grip ratio of one or less than one or, to put it differently, that 25 per cent showed varying degrees of greater strength in their left hands than they evidenced in their right hands. And, accordingly, it was found that 75 per cent had greater strength in varying degrees in their right hands than they had in their left hands. The mean amount of strength per person in the entire group as measured by the grip test was found to be $1.100 \pm .005$. The chances are 999 out of 1,000 that any other sample will be within the range of 1.100 ± 4.88 times the probable error, or between 1.124 and 1.076. The standard deviation was found to be $.117 \pm .003$. The frequency distribution will be observed in Table No. 17:

A second observation was made on the validity of the tapping test. The reported handedness of 265 college students was compared with the handedness ratios which they actually made on the tapping test. It is interesting to note that with the exception of three subjects: all who said they were left-handed, indicated the same by their tapping, the three subjects who did not indicate left-handedness in their tapping rate did not in any instance have a handedness ratio of above 1.04.

The fifth factor in the college group to be studied was investigated after the results of the other studies had been completed. This study was designed entirely to study the effect of training on dextrality. It was believed that in this way the environmental effect on dextrality

TABLE NO. 17

COLLEGE STUDENTS—FREQUENCY TABLE—GRIP TEST

Class Interval	Deviation From *Assumed Mean x	Frequency f	First Moment	Second Moment
.80	—.30	2	—.60	.1800
.85	—.25	2	—.50	.1250
.90	—.20	6	—1.20	.2400
.95	—.15	13	—1.95	.2925
1.00	—.10	38	—3.80	.3800
1.05	—.05	44	—2.20	.1100
*1.10	0	44	0	0
1.15	.05	29	1.45	.0725
1.20	.10	25	2.50	.2500
1.25	.15	20	3.00	.4500
1.30	.20	10	2.00	.4000
1.35	.25	4	1.00	.2500
1.40	.30	2	.60	.1800
1.45	.35	2	.70	.2450
1.50	.40	1	.40	.1600
		242	1.40	3.3350 = S^2

*Assumed mean = 1.10.

Calculations: Same symbols as used previously. $\Sigma^2 = S^2 - x^2 =$ 3.3350 where $x = 1.40/242 = .00578$.

$o'^2 = \Sigma^2/N = 3.335/242 = .01379752$.

$o' = \sqrt{.01379752} = .1174$.

Probable Error of Mean $= .6745 \times .1174/\sqrt{242} = .0051$.

Mean = M = 1.106 ± .005.

Probable Errors of $o' = .4769 \times .1174/\sqrt{242} = .0036$.

Standard Deviation = $o' = .1174 \pm .004$.

---

could be measured, and it was believed that if the percentage of improvement were small in the non-preferred hand, evidence would be at hand that was indicative that handedness was a native trait, and that if the percentage of improvement were large, evidence would be at hand that handedness was an environmental trait. In the realization that the college student had been in a right-handed world about 20 years, and that in the finer co-ordinations involved in writing, one could more easily discern the effects of training, a number marking test was given each of 343 college students. Realizing further that the right hand was very probably nearer its maximum achievement, two practice periods of 30

seconds each were given each hand alternately after the initial practice period for each hand of 60 seconds.

The technique of the test involved the crossing out of numbers on a sheet of numbers just as rapidly as possible. Only .05 per cent of the entire 343 were found to mark either the same number of numbers out with their right and left hands or fewer numbers with their right hand than with their left. The mean of the entire distribution was found to be 1.61 ± .015. The chances are 1,000 to one that any other random sample will fall within the range of 1.61 ± 4.88 times the probable error. The standard deviation was found to be .420 ± .011. The frequency distribution will be observed on the following page, see Table No. 18.

The two 30-second practice tests led to interesting results which can be most clearly appreciated in chart form as shown in Figure 18.

The consideration of those subjects who were left-handed in the above two charts of left-handed subjects very probably can merit only slight significance because there was data for only 11 cases in chart number one, and for only six cases in chart number two. For the 11 cases in chart number one we find the left hand, the preferred hand, in this instance, making the greatest improvement and having the smallest regression in the practice periods. For the six cases in chart number two the same thing is true. While for the 343 right-handed cases exactly the reverse is true, for the improvement of the non-preferred hand. In both charts for the right-handed subjects, by a large percentage, it is the non-preferred hand which shows the greatest improvement and also the greatest regression. Certainly, these studies of improvement for right-handed subjects seem to indicate that the right hand in its normal functioning is much nearer the limit of its activities than is the left hand, and that were the conditions of our world equally as stimulating to left-handed performance as they are to right-handed performance, the percentage of left-handed performance would be increased by about 13.6 per cent. The 13.6 per cent is the average of the two percentages of greater improvement shown by the left hand than was shown by the right hand in the two 30-second training periods after the initial 60-second testing period. It is interesting to compare the 13.6 per cent greater improvement shown by the left hand over the right with the 12.2 per cent of college students who indicated varying degrees of left-handedness in the tapping test and yet who showed themselves to use the right hand for the marking test with its involvement of the finer co-ordinations used in writing.

TABLE NO. 18
FREQUENCY DISTRIBUTION

Class	Deviation From *Assumed Mean	Frequency	First Moment	Second Moment
.60	—1.00	3	—3.00	3.00
.70	— .90	4	—3.60	2.24
.80	— .80	4	—3.20	2.56
.90	— .70	3	—2.10	1.47
1.00	— .60	5	—3.00	1.80
1.10	— .50	10	—5.00	2.50
1.20	— .40	12	—4.80	1.92
1.30	— .30	12	—3.60	1.08
1.40	— .20	33	—6.60	1.32
1.50	— .10	40	—4.00	.40
*1.60	0	44	0	0
1.70	.10	33	3.30	.33
1.80	.20	34	6.80	1.36
1.90	.30	18	5.40	1.62
2.00	.40	20	8.00	3.20
2.10	.50	16	8.00	4.00
2.20	.60	21	12.60	7.56
2.30	.70	9	6.30	4.41
2.40	.80	6	4.80	3.84
2.50	.90	5	4.50	4.05
2.60	1.00	7	7.00	7.00
2.70	1.10	3	3.30	3.63
2.80	1.20	1	1.20	1.44
		343	32.30	60.73 = S^2

*Assumed Mean = 1.60

Calculations: Symbols same as previously used.

$\Sigma^2 = S^2 - X^2 = 60.73 - (.09)^2 = 60.7219$

$X = \frac{32.3}{343} = .094$

Mean = 1.60 + .094 = 1.694

$\delta^2 = \frac{\Sigma^2}{N} = \frac{60.7219}{343} = .177032$

$\delta = \sqrt{.177032} = .421$

Probable Error of Mean $= \frac{.6745\delta}{\sqrt{N}} = \frac{.6745 \times .421}{\sqrt{343}} = .0153$

P. E. $\delta = \frac{.4769\delta}{\sqrt{N}} = \frac{.4769 \times .421}{\sqrt{343}} = .011$

Mean = 1.694 ± .0153; δ = .421 ± .011

TABLE 19

AVERAGE PER CENT IMPROVEMENT NUMBER MARKING TEST
1ST AND 2ND TEST

	Left-handed Subjects				Right-handed Subjects			
	Right Hand		Left Hand		Right Hand		Left Hand	
	+	—	+	—	+	—	+	—
Number	7	4	8	3	199	144	297	46
Average Percentage Improvement	19.2	26.5	30.7	6.2	9.6	8.4	18.2	12.1

\+ = Improvement
— = Regression

1ST AND 3RD TEST

	Left-handed Subjects				Right-handed Subjects			
	Right Hand		Left Hand		Right Hand		Left Hand	
	+	—	+	—	+	—	+	—
Number	5	1	5	1	84	62	158	3
Average Percentage Improvement	30.6	42.1	45.3	6.4	11.1	7.2	39.7	34.1

(To be concluded in the April issue.)

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FUNCTIONAL EYE STRAIN*

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Eye strain, insofar as it is amendable to refractive correction, is a question of functionability and has its inseption in subnormal accommodation or subnormal convergence. It is usually reflex, but may be objectively manifest in local pathologies such as blepharo-spasm, chronic conjunctivitis, simple blepharitis marginalis or of the compound variety exhibited by multiple cysts due to concurrent breaking down of a number of adjacent meibonian glands. The best evidence that accommodative strain is the etiological factor of blepharitis lies in the fact that there is no known record of this disease occurring in conjunction with myopia, and we have never observed a permanent cure effected without the proper correction of the hyperopia which is always present with this condition. The reason for this is revealed in the study of that part of the functional anatomy of the eye which shows that the meibonian glands derive their innervation from branches of the third pair of cranial nerves which also supply the ciliary muscles.

Logically, when compensation for the hyperopia is insufficient those branches which supply the ciliary muscles appropriate more than their share of innervation with the result that the meibonians are impoverished and functionally impaired with the results noted. Further proof that blepharitis has a functional origin is found in the fact that it is not infectious, therefore not a germ disease.

Treatment obviously must be directed to removal of the cause, i.e., the correction of the refractive error which together with hygienic measures in the way of a thorough cleansing of the affected parts twice daily is usually sufficient to effect a cure, but may in the more exaggerated cases be supplemented by astringents. Surgical procedure is indicated only when indurated cysts or chlazions are encountered. A peculiar differentiation is noted in the fact that objective evidence of eye strain is seldom associated with subjectively manifest symptoms. On the other hand, the worst subjectively reflex cases of eye strain are very frequently associated with a clear, a clean, non-pathological eye and normal or even a hyperacuity of vision. Reflex eye strain is usually of the accommodative variety, occurr-

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ing in low degrees of hyperopia and hyperopic astigmatism, with little or no impairment of visual acuity.

Taking into consideration the fact that every hyperope is born and carries with him all through life a definite liability to accommodative strain and the myope a corresponding immunity, it would seem that diagnosis and treatment should be comparatively easy, but my contention is that refractive measurements alone are not only insufficient and indefinite, but frequently misleading, for the following reasons: In the first place, approximately seventy-five per cent of all the hyperopes are free from strain by virtue of complete physiological compensation and the majority of those requiring correction have partial compensation in varying degrees. Our best end-results, whether we realize it or not, are obtained by nicely bridging the gap between the actual anatomical deviation and the amount of compensation present. Secondly, there are many other known etiological factors which produce the same individual symptoms such as headache, vertigo, neurasthenia, etc. An error of refraction produces eye strain only in proportion to the effort involved in attempting to overcome it, and it is nearly always in inverse proportion to the amount of the error. Whereas, the patient with a low degree of hyperopia usually can and does obtain and maintain satisfactory vision at the expense of his accommodation and in the absence of sufficient compensation suffers from undue loss of nervous energy; the one of higher degree may waste no energy attempting to accomplish an impossibility.

Complete compensation for low error is usually present in youth but loss of accommodative compensation, with its attendant discomfort, may occur during the next term of school or it may endure indefinitely up to the age of presbyopia. The difference between the woman who is really ill for the want of a pair of plus spheres and her sister with double the error but no strain, lies in their respective accommodative powers. The woman of thirty-five years, for example with a headache, vertigo and an error of refraction. These symptoms may be, and frequently are, correlated, but we must take into consideration the fact that she has several neighbors with the same refractive error but none of her symptoms, and as many more neighbors who have the same identical symptoms which have been clinically proven to be due to various non-ocular causes, such as auto-intoxication, albuminuria, lacerated cervixes or foci of infections. A visit to ten different men specializing in as many different lines may result in ten different interpretations of the same symptoms and as many different diagnoses. Symptomatic diagnoses usually result in symptomatic cures with the etiological factor still a mystery. Third, the very act of eliminating an accommodative strain frequently induces a binocular strain, which did not previously exist, by disturbing the previously existing harmonious relation between accommodation and convergence.

Further reference to the third pair of cranial nerves shows that accommodation and convergence derive their innervations from the same source, and it is therefore impossible to place a pair of lenses before any

pair of seeing eyes without changing the previously existing relation, and the change is either good or bad, never neutral. Whenever we correct a hyperope, we lower the accommodative stimulus and concurrently deprive the convergence of a corresponding amount of habitual and sympathetic innervation, and unless our patient has a tendency to over-converge, this results in a binocular convergence insufficiency.

Let us consider a hypothetical case of a patient thirty-five years of age with one diopter of uncorrected hyperopia who complains only recently of discomfort. Nature has until recently taken care of the error of refraction by means of a physiological hypertrophy of the ciliary muscles and a corresponding hypertrophy of the external rectus muscles to check the natural tendency of all hyperopes to over-converge with the result that up to the time of his complaint he has maintained normal vision, normal accommodation and a normal relation between these functions, but the time has arrived when, on account of the increased resistance of the crystalline lens concurrent with advancing age or perhaps a change of occupation involving more eye work, the correction of his hyperopia has become imperative to eliminate an accommodative strain. What is the result? The physiological hypertrophy of the externi which up to the moment of his correction has been a benign influence, immediately becomes malign and a binocular strain ensues as a perfectly natural sequence.

It is generally conceded that the excessive accommodation required to overcome uncorrected hyperopia is the cause of most cases of convergent strabismus. When a cross-eyed child is presented for examination we hope to find a high degree of hyperopia, but we cannot ignore the fact that if plus lenses straighten cross-eyes and relieve esophoria by the same identical process they upset orthophoria and induce or aggravate exophoria. Furthermore, true exophoria sometimes stimulates esophoria through tonic contraction of the interni in the same manner that hyperopia sometimes stimulates myopia through spasm of accommodation. This leads me to believe that the most essential measurements are those of accommodation and convergence, with a corresponding analysis of their relation. Practically all of our lecturers and authors have divided this subject into three parts, namely: refraction, accommodation and convergence, but somehow have failed sufficiently to impress us with the importance of the last two subjects.

Subnormal accommodation from any source at any age, whether due to hyperopia or presbyopia, pathological, induced cycloplegia or to a generally neurasthenic condition, is indicated by recession of the near point. Mathematical estimation of accommodation requires simply a knowledge of the amount of divergence present from any given distance.

Light radiates from all luminous objects and enters the eye divergently from all finite distances, and the less the distance the greater the divergence. Whereas, the emmetropic eye is physically adjusted to all finite distances, all eyes are obliged to adjust themselves to finite distances by

the action of the ciliary muscles on the crystalline lens in order to overcome the difference between parallel and divergent rays of light. Light in its natural course travels in straight parallel lines called rays. Whenever we depart from parallelism we involve two angles, convergent or positive and divergent or negative. These angles are always equal whether acute, right angled or obtuse. In other words, the angle of convergence from any plane to any point is exactly equalled by an angle of divergence from that point back to the same place.

I will now briefly consider the subject of convergence, which is the power of the eyes to maintain binocular near vision. The demand for convergence, in common with accommodation increases in exact proportion to the proximity of the object, and I want to place special emphasis on the fact that a normal reserve convergence is just as essential to our well being as a normal reserve accommodation, and though binocular insufficiencies are less common than those of accommodation, correct diagnosis and intelligent prognosis must include the measurement of convergence, and that the acceptance or rejection of our refractive corrections, from a clinical standpoint, is more dependent upon the previously existing relations between these functions than to anything else. Practically all our socalled anomalies and idiosyncrasies are due to a nervous irritation arising from lack of harmony and proper co-ordination of the elements of functional vision. Weak convergence may co-exist with a normal distant co-ordination or even with esophoria, hence the measurement of convergence must not be confounded with tests for muscle balance at infinity.

Using the term asthenopia broadly to indicate any form of eye strain we may use the following synopsis: Asthenopia is due to excessive effort. The essential efforts are accommodation and convergence. The essential remedies are artificial accommodation and convergence; therefore the most scientific and at the same time the simplest method of relieving eye strain consists in restoring the near point of both accommodation and convergence, thereby establishing a normal functionability.

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THE TECHNIQUE OF REMOVING A FOREIGN BODY FROM THE ANTERIOR SURFACE OF THE CORNEA*

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How many optometrists meet with misgiving the person who enters their office and asks that a cinder be removed from the eye. I, for one, had this feeling until some time ago when I developed a technique for their removal which is simple, effective, and quick. The equipment needed is to be found in the offices of most of our men, save that I find many men lack a good binocular loupe.

It is essential that the first step in handling such a patient is to examine minutely and under high magnification, if necessary, his eye to determine just where and what the foreign body is. If the foreign body is a cinder on the cornea, and this is the most common occurrence, then it is necessary with your loupe to determine whether it is so deeply imbedded in the cornea that it can not be removed by an eye snare. Now the eye snare should be one of the variety with the long handle like a pencil, so that it can be more accurately manipulated than the common variety. Also I think it is better that it should be a fine wire rather than a hair, because the fine wire will get under a cinder which a coarser hair passes over. In addition to this it can be sterilized. Armed then with a good light, the person seated in the chair with his head well back on the head rest, one can usually see with the unaided eye just what the trouble is. Often, however, the cinder is up underneath the eyelid which, of course, may be rolled up by grasping the edge of the lid and eyelashes in one hand and rolling it back over a small wooden spud. This operation is greatly assisted by having the patient look down. A cinder on the under side of the eyelid is, of course, readily removed with a snare. If, however, the cinder is on the cornea I have found it wise to use a special motion in removing this. The best description of this motion is, that you make a series of little circles with the end of the snare at a point as close to the foreign body as you can get without touching it. After making a few of these little swings to get your muscles attuned to get for you, the right stroke you wish then, let one circle be just large enough to bring your snare in contact with the cornea at the point where the cinder is imbedded, and in 95 cases out of 100 the trick is done. The

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cornea has been touched only once. This touch was delicate, at the right spot, quick, somewhat painful to be sure, but since you usually only need to do it once, it gets the patient out of his troubles as quickly and easily as possible. To attempt to work slowly and get your snare slowly down to position in front of the eye and then make this same stroke does not work as well. The person seems to sense your tenseness and uncertainty just at the critical second and the eye turns away and your troubles begin.

This may seem a minor point upon a very small and simple subject, but I feel that it is one which should be handled with great nicety in every optometric office. Nevertheless, a very small cinder makes a very uncomfortable patient and it is well to know how to relieve this discomfort. One should be in position to see well by having a good light and good loupe and with the rotating motion technique just outlined the eye is not startled by any sudden motion and will maintain its position until you have actually lifted off the cinder, or small foreign body.

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PSYCHOTHERAPY AND PAIN

No study of the symptom "pain" is complete without going into its psychic phase. Hence psychic measures must usually be included in the stratagem of relief. For our optometric patients there are a number of psychic vicious circles that may have to be interrupted before the case can be successfuly discharged. For instance, ocular pain creates anxiety, which concentrates attention on the eyes and vision, which in turn increases the appreciation of the ocular pain, for attention acts like a focussing lens. Allaying anxiety in itself raises the pain threshold and makes possible the relief of pain with much milder means than are required to remove the appreciation of a pain when fear is left to run unchecked. It is in this manner that explanation and reasoning act on those patients whose minds are still accessible to reason. In those whom either their nature or the pain engendered panic has made incapable of reasoning, nothing but the potency of suggestion will allay the anxiety and the optometrist who does not understand how and when to employ suggestion, deserves the inevitable defeat he will meet in handling ocular cases of this sort. Obviously, prompt and drastic relief of ocular pain and other visual symptoms has in itself a high degree of suggestive value.

The one form of pain best relieved by purely psychic means is an ocular-psychalgia, which may be defined as an intra-ocular pain combined with a general head-pain, these without adequate physical, refractive or muscular causation. Such pain may be visualized, says Fantus[1], as being due either to removal of the inhibitory control that the cerebral cortex exerts on the subcortical centers (e.g., the optic thalmus) or to an excessive irritability of the lower sensory neurons, so that sensations generally disregarded or merely spoken of as distress, become appreciated as pain. The diagnosis of phychalgia is suggested by absence or inadequacy of physical or chemical causes, by such stigmas of neurosis as unanatomic distribution of the pain, as well as by the relief secured by purely physchic means. It is not admissible, however, to conclude merely on the basis of relief by psychic measures that organic causation is absent. At the most, such a result enables one to recognize a psychic contributing factor.

Psychoanalysis, at times even may enable the optometrist to recognize the symptomatic nature of a pain, and the demonstration of this interconnection may cure it.[2] The symptom pain, may be a psychic example of escape mechanism, in other words, a way out of an intolerable situation. In a case of this sort the latter will have to be dealt with. The headache the patient complains of may mean, "This or that is disagreeable to me, and I don't want to do it any longer." In pure ocular-psychalgia the ordinary treatment with glasses and orthoptic treatment measures is a grave mistake. It merely fixes the patient's conviction of the presence of an ocular abnormality and focusses his attention on his eyes. The technic of neglect, which may be defined as paying no attention whatever to the eyes while giving solicitous care to the mental wellbeing of the patient as a whole is frequently useful in these cases. The optometrist must ever beware of pathogenic suggestion, such as ascribing the pain complained of to a refractive or muscular condition present but inadequate to cause the pain. Thus the diagnosis "astigmatism" may make the ocular-psychalgic case incurable by anything else but an unnecessary pair of glasses or perhaps by some other adequate suggestion. It must be remembered that mere symptomatic relief of ocular-psychalgia, which is frequently easy, does not suffice to prevent a recurrence of the condition. It should be just the starting point for what is called a psychic alterative therapy or for a real program of better mental hygiene. Cases of ocular-psychalgia are frequently encountered in optometric practice and every optometrist should be on his guard to give these cases the type of mental therapy their case demands. C. C. K.

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[1] Fantus, B. Psychotherapy. Jour. of the Amer. Med. Assn. Vol 103, No. 25, p. 1940. 1934.

[2] Koch, C. C. Psychotherapy and Refraction. Amer. Jour. of Optom. Vol 10, No. 11, p. 421. 1933.

THE APPLICATION OF HEAT IN ORTHOPTIC TREATMENT WORK

According to Kurtz[1] who also quotes Kellogg[2], the application of hot packs in certain ocular conditions lessens general nervous sensibility. This they claim, is due to the absorption of moisture by the terminal nerve filaments in the skin or perhaps by the stimulation of the temperature of the nerve endings. These hot packs generally produce an agreeable sense of comfort and well being.

This sense of comfort and well being is one which we as optometrists should seek to produce, especially in these cases where an involvement of the extra-ocular muscles is causing some nervous irritability or even pain. As an adjunct to our regular orthoptic treatment technics with prisms, it is well, the writer believes, to resort to the clinical application of heat at the close of each treatment period.

Whenever there is pain, the application of heat is a most useful remedy. Whether one applies moist hot-packs, the small electric heating pad, the hot water bag, diathermy, or radiant energy in the form of an infra-red lamp, the effect is essentially the same, though differing somewhat in degree of action yet all are noted for their suitableness in certain ocular orthoptic treatment work. To be sure, the hot water bag, the favorite domestic analgesic, suffers from the disadvantage of its weight, which may make it intolerable whenever there is much ocular tenderness. The electric heating pads are free from this objection, but must be watched much more closely. These types of heating appliances along with the moist hot-pack are particularly indicated when the relaxing effect of warmth and moisture favors a lessening of tension. When relaxation of tissue is not demanded the writer has found[3] radiant energy in the form of diathermy the most convenient analgesic to be invoked. In this same connection Shepard and Mendelsohn[4] suggest the use of the infra-red lamp.

The writer has found that a deep seated muscular involvement may be more effectively relieved by diathermy than by any of the other methods of applying heat to the closed lids, but other methods of application of heat generally do quite as well. Whenever heat is employed, scrupulous care must be exercised against burns. The writer has also found the following technic to be of value. At the close of a treatment, when heat has been used, cold applications or packs are applied for

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[1] Kurtz, J. I. Ocular Physical Therapy for Optometrists. Amer. Jour. of Optom. p. 181. 1930.

[2] Kellogg, J. H. Light Therapeutics. p. 48.

[3] Koch, C. C. The use of infra-red radiation in orthoptic work. Amer. Jour. of Optom. Vol. 10, No. 3, p. 106. 1933.

[4] Shepard, C., and Mendelssohn, W. The use of infra-red radiations in orthoptic work. Post-graduate Eye Institute Monthly Report. December, 1932.

several minutes. This serves to fix-the-blood-in-the-tissue, and acts as a finishing procedure, the hyperemic reaction of which is then more lasting than is the hyperemia remaining after the discontinuance of the heat alone. —C. C. K.

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BOOK NOTICES

THE PRACTICE OF REFRACTION. Sir Stewart Duke-Elder, M.A., D.Sc., Ph.D., Ophthalmic Surgeon and Lecturer in Ophthalmology, St. George's Hospital, London. Second Edition. Published by the P. Blakiston's Son & Co., 1012 Walnut St., Philadelphia, Pa. 381 pp., Illustrated. Cloth. $4. 1934.

In the present edition the author follows the general outline of the previous work but has added material in the sections dealing with myopia and the orthoptic treatment of squint. Ocular hygiene too, comes in for more mention than in the first edition, particularly with reference to the general hygienic treatment advised in specific types of refractive cases. The author, a British surgeon, naturally approaches the subject of ocular refraction from the continental European viewpoint, and therefore the American reader misses such familiar references as Dynamic Skiametry and Accommodative-Convergence imballances, etc. He does, however, treat in a very thorough manner all forms of refractive and ocular neuro-muscular imballances and goes into detail explaining the procedures used in correcting these defects. He also gives in table form (1) the Refractive Indices of various types of ophthalmic glass, (2) table showing the equivalents of centrads in prism dioptres, in degrees of deviation and in degrees of the refracting angle, (3) Percival's table of Metre angles. The book is well written and illustrated, is a handy reference volume, and may be highly recommended for both the student and practitioner. —C. C. K.